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PB-290 916

The Economic Impact Analysis of Effluent Standards for Total Dissolved Solids

Illinois Inst of Natural Resources, Chicago

Oct 78

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THE ECONOMIC IMPACT ANALYSIS OF EFFLUENT STANDARDS FOR TOTAL DISSOLVED SOLID

Document No. 78/12

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U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

REPORT DOCUMENTATION PAGE		1. REPORT NO. Document No. 78/12	2.	3. Recipient's Accession No. PB290916
4. Title and Subtitle The Economic Impact Analysis of Effluent Standards for Total Dissolved Solid		5. Report Date October, 1978		
7. Author(s) Linda Huff (L)		6.		
9. Performing Organization Name and Address Same as box 12		8. Performing Organization Rept. No.		
12. Sponsoring Organization Name and Address Ill. Institute for Natural Resources 309 W. Washington St. Chicago, IL. 60606		10. Project/Task/Work Unit No. 80.132		
15. Supplementary Notes		11. Contract(C) or Grant(G) No. (C) (G)		
16. Abstract (Limit: 200 words) The Illinois Effluent Standards Advisory Group (IESAG) has recommended elimination of the present total dissolved solids (TDS) effluent standard in Illinois. Presently the effluent standard prohibits an increase of more than 750 mg/l above the abckground concentration, except where resulting from waste treatment or recycle. In these two instances, a maximum of 3500 mg/l TDS would be permitted. The elimination of this standard would benefit potable water treatment plants, electric generating stations, and industrial discharger. Reduction of analytical costs and elimination of potential treatment expenses are regarded as benefits of the proposed change. Environmental impacts are considered the costs incurred. Water users continue to pay additional expenses for operation because of the total dissolved solids concentration in streams. The effects upon each group of adopting the proposed change is summarized herein.		13. Type of Report & Period Covered		
17. Document Analysis a. Descriptors Water Pollution Dissolved Organic Matter b. Identifiers/Open-Ended Terms Illinois Total Dissolved Solids Water Pollutants c. COSATI Field/Group 14A Cost effectiveness		14.		
18. Availability Statement Unlimited distribution by U.S. EPA		19. Security Class (This Report)		21. No. of Pages 94
		20. Security Class (This Page)		22. Price A05-A01

(See ANSI-Z39.18)

See Instructions on Reverse

 OPTIONAL FORM 272 (4-77)
 (Formerly NTIS-35)
 Department of Commerce

DOC. NO. 78/12
October, 1978

THE ECONOMIC IMPACT ANALYSIS OF EFFLUENT STANDARDS
FOR TOTAL DISSOLVED SOLIDS

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NOTE

This report has been reviewed by the Institute of Natural Resources and approved for publication. With the exception of the Opinion of the Institute's Economic Technical Advisory Committee, views expressed are those of the contractor and do not necessarily reflect the position of the IINR.

Printed by Authority of the State of Illinois

Date Printed: October, 1978
Quantity Printed: 300

This document has been cataloged as follows:

Huff, Linda L.

The economic analysis of effluent standards for total dissolved solids. -- Chicago : Illinois Institute of Natural Resources, 1978.

94 p. ; 28 cm. -- (Doc. No. 78/12)

1. Economic impact statements. 2. Total dissolved solids - economic impacts - Illinois.
I. Title. II. Illinois Institute of Natural Resources, Division of Environmental Management.

IINR Environmental Information Center

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Opinion of the Economic Technical Advisory Committee
of the Illinois Institute of Natural Resources

The Economic Technical Advisory Committee has reviewed the economic impact study IIEQ Document No. 78/12, entitled Economic Impact Analysis of Effluent Standards for Total Dissolved Solids, R76-21. The Committee finds the report to be generally responsive to the requirements of Section 6 of the Environmental Protection Act and recommends that it be forwarded to the Pollution Control Board so that public economic impact hearings may be held in conjunction with proposed regulation R76-21, EFFLUENT STANDARDS REVISIONS, which seeks to amend rule 408 of Chapter 3, Water Pollution Regulations.

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SUMMARY

The Illinois Effluent Standards Advisory Group (IESAG) has recommended elimination of the present total dissolved solids (TDS) effluent standard in Illinois. Presently the effluent standard prohibits an increase of more than 750 mg/l above the background concentration, except where resulting from waste treatment or recycle. In these two instances, a maximum of 3500 mg/l TDS would be permitted.

The elimination of this standard would benefit potable water treatment plants, electric generating stations, and industrial dischargers. Reduction of analytical costs and elimination of potential treatment expenses are regarded as benefits of the proposed change. Environmental impacts are considered the costs incurred. Water users continue to pay additional expenses for operation because of the total dissolved solids concentration in streams. The effects upon each group of adopting the proposed change is summarized herein.

Water Quality Impacts

In 1977 and 1978 only 1% of all water quality samples collected exceeded the general use total dissolved solids water quality standard. There appears to be a regional pattern in TDS concentrations and this is attributed to man's activities and geological phenomena. The highest levels of dissolved solids are recorded in mining areas and northeastern Illinois, and all water quality violations occurred in these two regions.

To evaluate the effect of eliminating the TDS effluent standard, the relative magnitude of TDS contributions received from point and non-point sources were computed. Table 1 depicts the estimated impact of

Table 1
TDS MASS BALANCE FOR ILLINOIS

Source	Average TDS Discharged to Illinois Waterways, 10 ⁶ lb/day	Percent of Total TDS ¹ Loading, %
Background from Lake Michigan	2.85	6.5
Domestic waste contribution	1.90	4.3
Background from municipal ground water	1.25	2.8
Background from industrial ground water	1.08	2.4
Road de-icing	1.64	3.7
Irrigation	0.19	0.4
Industrial contribution		
Dischargers <1000 mg/l	4.16	9.4
Dischargers >1000 mg/l		
Contribution of 1st 1000 mg/l	0.74	1.7
Contributions of >1000 mg/l	0.64	1.5
Storm-water runoff	<u>28.9</u>	<u>65.5</u>
Total	43.35	98.4

¹Average TDS leaving the state via the seven rivers presented in Table 2-4 is 44.1×10^6 lb/day.

eight major sources. These results indicate that storm water runoff accounts for 65% of the total TDS pound loading found in Illinois rivers. The industrial contribution which would be impacted by the rule change is only 1.5% of the total TDS loading. This is less than the effects of background water from Lake Michigan, road de-icing, domestic waste contribution, and even background from municipal ground water. Thus, the existing effluent standards only impact regulates 12.5% of the total TDS loading discharged, and, in fact, only 1.5% of the state TDS concentration would be directly effected by elimination of the standard. It is this water quality result which is utilized to determine the environmental costs.

Environmental Costs

Table 2 summarizes the anticipated effects upon surface water users in Illinois. Those costs quantitatively expressed are associated with domestic water use, industrial water use, and electric generating stations' cooling water use. Increased operating costs of \$231,000 per year are associated with elimination of the standard. Effects upon agriculture, recreation, and general stream ecology are qualitatively discussed; however, there appears to be no significant environmental change associated with this rule change.

Benefits of Proposed Change

The benefits of eliminating TDS regulation accrue to 87 potable water treatment plants, 14 electric generating stations, and 19 industrial dischargers. Presently there are small water treatment plants which utilize zeolite softening and discharge a brine waste to streams. These

Table 2

SUMMARY OF ENVIRONMENTAL IMPACTS

Page ____ of ____

COST CATEGORIES	LEVEL OF INFORMATION							EXPLANATORY REMARKS
	QUALITATIVE COST ASSESSMENT	REFERENCE	QUANTITATIVE COST ASSESSMENT					
			Amount of Cost	Units of Measure	Range of Cost Uncertainty	\$ Value	Range of \$ Uncertainty	
1. Residential water user	Increased costs due to accumulation of minerals in household appliances.	8	Change of	0.6 mg/ l	+20%	158,000	+16,000	Areas of high TDS occurrence are not affected by the proposed rule change. Areas of high TDS occurrence are not affected by the proposed rule change. Although changes in stream ecology may occur toxic effects appear above the water quality standard. No streams impacted in this study are at such levels.
2. Industrial water user	Increased operating costs due to scale formation from minerals.	5	Change of	0.6 mg/ l	+20%	68,400	+ 7,000	
3. Power Generation	Increased operating costs due to scale formation from minerals.	5 (See appendix)	Change of	0.6 mg/ l	+ 20%	4,600	+ 500	
4. Agriculture	Crop reduction due to high TDS values when land is repeatedly irrigated.	10	-	-	-	None	-	
5. Human Health	Laxative effects or unpleasant taste occur in high TDS water.	9	-	-	-	None	-	
6. Ecology	TDS levels harmful to vegetation or wildlife occur over 1500 mg/l.	10	-	-	-	None	-	

plants save on potential costs for hauling brine away or ceasing operation. The population which realizes these savings is 121,681 people in 87 communities.

Fourteen electric generating stations will save money on analytical costs. Although a potential cost for TDS treatment exists, especially after the variance expiration in 1979 for Commonwealth Edison, no treatment cost savings were assigned to these dischargers.

There are 19 industrial dischargers monitoring for TDS in their effluents; however, only four plants would be saved the potential costs of treatment for TDS by reverse osmosis. The costs savings for this group is thus a combination of reduced analytical costs and potential elimination of treatment facilities.

Table 3 presents the savings for these affected dischargers. The potable water treatment plants represent a reduction in capital expenditure as large as \$9.13 million and the four industrial dischargers save up to \$6.6 million on reverse osmosis facilities which are not required. Total annual cost savings of \$1.04 million to \$8.24 million for these three discharger categories are realized when the existing TDS standard is eliminated.

Benefit-Cost Analysis

In considering the economic reallocation of resources, an "efficient" modification of the pollution regulations would result in benefits greater than the costs imposed. Potential economic damage to municipal water users, industrial sources and power plants totalled \$231,000 per year. The annual savings in analytical costs and treatment costs ranged from \$1 million to \$8 million. Both the statewide costs and benefits are

Table 3
TOTAL SAVINGS TO IMPACTED DISCHARGERS

Discharger Group	Annual Savings, \$	Capital Investment Eliminated, \$, millions
Water treatment plants or option a	493,000-1,649,000	9.13
option b	7,694,000	0.87
Electric generating station monitoring	5,760	-
treatment	-	-
Miscellaneous monitoring	6,840	-
treatment	533,900	6.6
Total ¹	1,044,500-8,245,500	\$7.47-15.73

Note: ¹Totals reflect the inclusion of either option "a" or "b" under water treatment plants.

large; however, the savings or benefits exceed the costs of adopting the proposed rule change. Considering the magnitude of point source versus non-point source contributions of dissolved solids and the economic impact of the proposed change, the elimination of the effluent TDS standard is warranted.

Economic Impact

The economic impact of eliminating the TDS effluent standard is based upon increased operating costs for surface water users and savings to potable water plants, electric generating stations, and industrial dischargers. No impact upon agricultural or commercial activity is observed as a result of the rule change. Nineteen industrial dischargers will reduce analytical costs and treatment requirements by \$538,900 per year while all other industrial surface water users will continue to incur slightly higher operating costs totalling \$68,400 per year. This continued operating cost of \$68,400 should not affect industrial output or product price in Illinois.

No changes in municipal services or taxes beyond existing levels will occur as a result of the proposed rule elimination. The incremental costs of \$158,000 per year will continue to be incurred statewide for homes using surface water for domestic purposes. Without the rule change, 87 potable water treatment plants serving 121,681 people would require increased costs of \$493,000 to \$7,694,000 per year. Thus, for municipalities and industry economic impact of not adopting the proposed change is much greater than that associated with the rule change.

Chapter 1

INTRODUCTION

The Illinois Effluent Standards Advisory Group (IESAG) has recommended modifications to the Illinois water pollution regulations after a review of existing treatment technologies. One recommendation, which is a part of the IESAG modification proposal known as R76-21, was that the effluent standard controlling total dissolved solids (TDS) be eliminated. Presently the effluent standard prohibits an increase of more than 750 mg/l above the background concentration, except where resulting from waste treatment or recycle. In these two instances, a maximum level of 3500 mg/l TDS would be permitted.

The lack of "proven conventional technology for control of TDS in wastewaters" was cited as the reason for deletion by IESAG. Non-conventional control technology, which is expensive, was thought to be warranted only in water quality limited receiving waters.

Elimination of the total dissolved solids effluent standard will benefit dischargers, such as water treatment plants and electric generating stations, since the potential for increased treatment costs would be eliminated. Increased costs are accrued by the users of water with higher dissolved solids standards. Specific uses, such as irrigation, domestic water supply, industrial water supply, and power generation water usage, would be affected by the elimination of the TDS standard.

To adequately depict the impact of this regulation upon the environment, the existing water quality and the TDS contribution of

point and non-point sources must be delineated. In Chapter 2 the importance of these two factors is developed.

The expected costs and benefits are developed upon a statewide basis with mention of particular industry segments who might be impacted in an economic sense. Chapter 3 describes the benefits of reduced monitoring and treatment costs for impacted dischargers, and Chapter 4 presents the environmental damages or costs incurred as a result of eliminating the total dissolved solids effluent standard. The magnitude of costs and benefits are compared and discussed in Chapter 5 and limits to the analysis are provided in Chapter 6.

Much of the data and methodology presented in this report are based upon the findings of a report by Huff and Huff entitled, "Economic Impact of Total Dissolved Solids Effluent Standards in Illinois," Document No. 76/17. The specific statewide impacts are more extensively reviewed and updated to reflect 1978 conditions.

Chapter 2

CURRENT AND ANTICIPATED ENVIRONMENTAL CONSEQUENCES

In evaluating the impact of a rule change, it is important to assess not only the existing effluent situation but also the water quality conditions within the state. Because dissolved solids are a natural occurrence in streams, the contributions of point and non-point sources should also be distinguished.

In this section, the existing stream concentrations, historical trends in water quality, and the significance of point source contributions are described. Total dissolved solids (TDS) are monitored by the Illinois Environmental Protection Agency (IEPA) and Illinois State Water Survey, and their information has provided the best explanation of the status of TDS in Illinois waters. Special mention is made of the water quality in the major drainage basins.

2.1 Regional Water Quality in Illinois Streams

The water quality criteria for Illinois streams vary according to the usage of the water in the stream. General stream standards apply to all waters in the state to protect aquatic life. Public water supplies and food processing waters require more stringent limitations for health and aesthetic purposes. The applicable total dissolved solids levels according to these criteria are the following:

<u>Water Use</u>	<u>Total Dissolved Solids, mg/l</u>	<u>Sulfates, mg/l</u>	<u>Chlorides, mg/l</u>
General Stream	1000	500	500
Public Water Supply and Food Processing Waters	500	250	250
Secondary Contact	-	-	-

A state-wide weighted average TDS concentration of 303 mg/l was reported in a recent study by Flemal and Nienkerk.¹ This study found that total dissolved solids levels in Illinois streams are consistent by regional area. Figure 2-1 shows the existing regional characteristics with respect to dissolved solids loadings. It is interesting to note that Flemal and Nienkerk observed no such regional pattern for some specific compounds, such as potassium, ammonium, and phosphate, while other parameters, including TDS, sodium, carbonate, and hardness, showed strong regional tendencies.

In Figure 2-1, there is a high TDS loading in northeastern Illinois and near southern Illinois. These trends are attributed, according to Flemal and Nienkerk,² to geological factors and regional point source contribution. The contour in the northeastern section which shows high TDS levels closely follows the boundary between younger and older glacial drift areas. The younger areas may leach considerably larger volumes of mineral material which would substantiate the higher levels reported. In the southern part of Illinois, the high TDS belt indicated corresponds to the major surface mining area of the state according to Flemal and Nienkerk.

Based upon the regional TDS patterns observed, one would anticipate

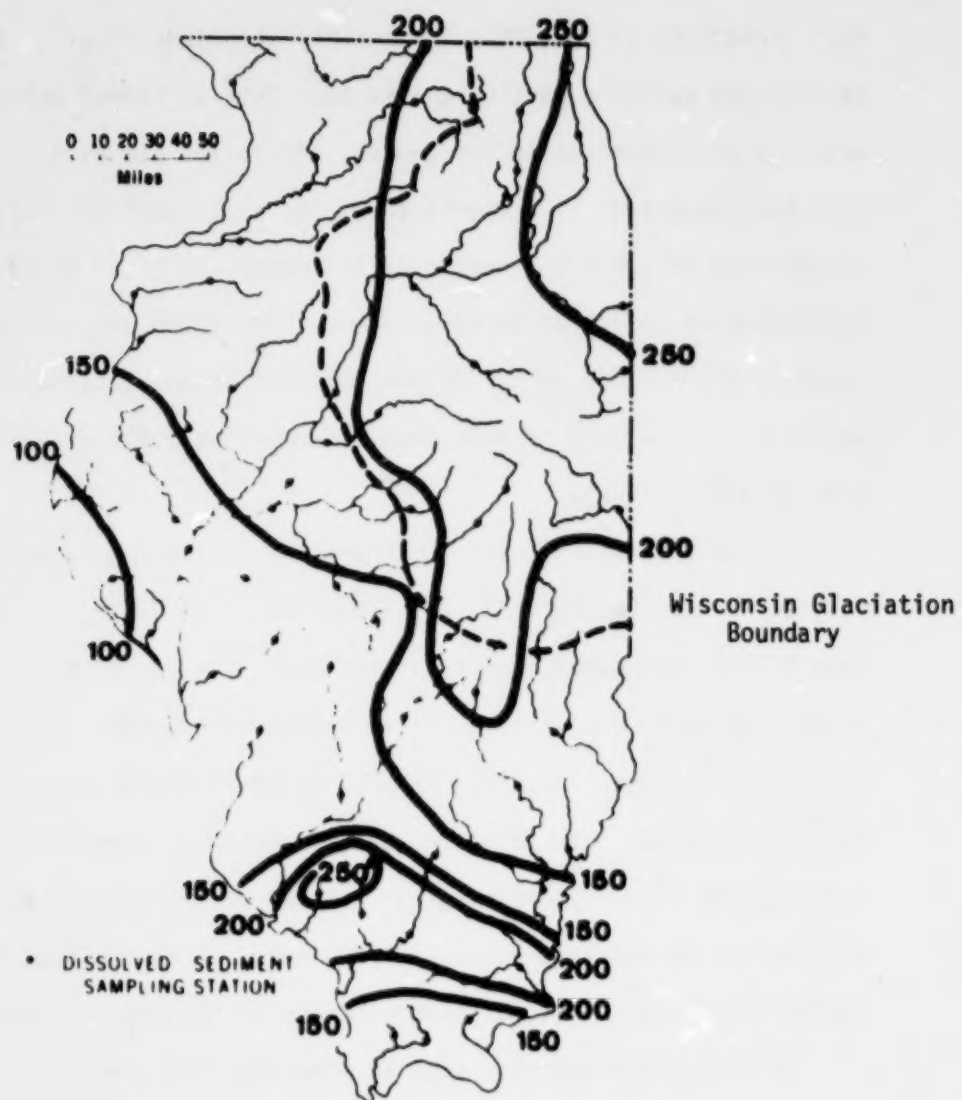


Figure 2-1 LONG-TERM YIELD OF TOTAL DISSOLVED SOLIDS (tons/sq mi/yr)

Source: Flemal & Nienkerk, 1976.

that violations of the TDS water quality standards occur in the northeastern and southern part of the state. This is indeed where the majority of violations in the general stream TDS standard (1,000 mg/l) have been reported. The magnitude of the water quality violations are categorized in Table 2-1 according to county. A total of 69 of the 6,953 samples collected in 1976-77, or 1.0% of the samples, were reported above 1,000 mg/l. Of the 585 monitoring stations on Illinois waterways, 21 had one or more samples above the 1,000 mg/l level (or 3.6% of the stations).

Of the 21 stations with TDS levels above 1000 mg/l, only two were located in northeastern Illinois; however, in 1974-75 this area accounted for over half of the water quality violations. The impact of urbanization as well as geological aspects of northeastern Illinois accounts for such high TDS concentrations. Planning Area 8, in which mining activities occur, represents another area of water quality concern. Seventeen samples reported dissolved minerals stream concentrations above 1,750 mg/l, with a maximum reported value of 6,300 mg/l. Planning Area 8 accounted for 63 of the 69 water quality violations in the entire state.

River basin areas were also examined for TDS levels above 1,000 mg/l. Table 2-2 which presents the river basins with high TDS concentrations based upon the 1977 IEPA monitoring data, demonstrates that the regional TDS patterns can be observed by the location of the affected rivers. The Des Plaines River in northeastern Illinois and the Saline and Big Muddy Rivers, which run through the surface mining areas, have the greatest number of stations with TDS levels exceeding 1000 mg/l. Regional water quality analyses thus indicate the areas of concern within Illinois.

Table 2-1
WATER QUALITY OF ILLINOIS STREAMS

Planning Area	County	Number of Water Quality Samples with Maximum Reported TDS Level:				
		1000-1250 mg/l	1250-1500 mg/l	1500-1750 mg/l	1750+ mg/l	Total
2	Will	2	-	-	-	2
6	St. Clair	-	-	-	1	1
8	Gallatin	3	4	1	-	8
	Hamilton	1	-	-	-	1
	Jackson	2	1	1	5	9
	Perry	-	2	2	1	5
	Pope	1	-	-	-	1
	Saline	8	9	7	6	30
	Williamson	3	2	2	5	12
	Total	20	18	13	18	69

Source: IEPA 1976-1977 Monitoring Data

Table 2-2
RIVER BASINS WITH HIGH TDS LEVELS

River Basin	Number of Stations with TDS > 1000 mg/l	Maximum TDS (mg/l) for Samples Taken
Saline	46	6300
Des Plaines	2*	1130
Mississippi (South)	1	1770
Big Muddy	20	2700
	—	
Total	69	

*These stations are located in secondary contact waters.

Source: IEPA monitoring data for 1976-1977.

2.2 Water Quality Trends

Effluent regulations have been promulgated at both the state and federal levels in order to protect the aquatic environment. Historical trends in water quality indicate a general deterioration during the 1950s and 1960s. By reviewing the historical trend of dissolved solids concentration in Illinois waterways, insight into the need for regulating dischargers of TDS can be obtained.

Flemal and Nienkerk¹ calculated the weighted average TDS concentrations at various sampling stations. Twelve sampling stations where data were available for more than one period are presented in Table 2-3. An increase in the TDS concentration was observed at nearly every station, with the average increase of 7% per five-year period or 1.4% per year. The Spoon River Station had the greatest increase, 48% in 10 years, of the stations investigated.

It is difficult to verify the existence of trends utilizing, in most cases, only two time periods. However, the large number of rivers exhibiting increases over the two periods strongly suggests there has been, and perhaps still is, a trend toward increasing TDS levels in Illinois waterways. A closer examination of the trend in TDS concentration for major river basins is provided.

2.2.1 Water Quality of the Mississippi and Illinois Rivers

As major watercourses, the Mississippi and Illinois River have a large flow, receive drainage from urban and rural areas, and have been monitored for many years. By analyzing water quality data from 1955 through 1972, the historical trend of the mean TDS concentration has

Table 2-3

TRENDS IN TDS CONCENTRATIONS
IN VARIOUS ILLINOIS RIVERS

Stream	Station Number	Sampling Period ¹	Weighted Average TDS Concentration, mg/l	% Increase (Decrease) Per 5-Year Period
Illinois River at Meredosia	104	3	314	+ 15 + 5
		4	360	
		5	379	
Kaskaskia River at New Athens	81	1	193	+ 6 0
		3	216	
		4	216	
Kaskaskia River at Shelbyville	105	3	297	- (9) + 17
		4	270	
		5	315	
Elkhorn Creek near Penrose	22	4	306	+ 2
		5	311	
Embarras River near Comargo	209	4	242	+ 14
		5	277	
Fox River at Algonquin	2	3	389	+ 1
		5	400	
Rock River at Como	23	3	323	+ 4
		4	335	
Seven Mile Creek near Mt. Vernon	207	4	189	+ 4
		5	197	
Skillet Fork at Wayne City	88	1	183	+ 1
		3	188	
Spoon River at London Mills	49	1	228	+ 24
		3	339	
Vermilion River at Lowell	39	3	314	+ 12
		5	388	
Wolf Creek near Beecher City	201	4	162	+ 7
		5	174	

¹ Sample Period: 1 = 1945-1950 4 = 1961-1966
 2 = 1950-1956 5 = 1966-1971
 3 = 1956-1961

Source: "Regional Distribution of the Major Dissolved Solids in the Streams of Illinois"

been ascertained. Figures 2-2 and 2-3 depict these trends with time. The maximum, minimum, and mean TDS values have been computed to illustrate the possible deviations which occur in any year. A regression analysis of TDS levels from 1955 through 1971 indicates the increasing trend depicted by the least-squares fit is statistically significant.* Or in other words, the progressive growth of the mean is not due to some random variation, but is increasing as a function of time.

The 1972-1974 data were not included in the analysis since a different, less accurate analytical test method was utilized in these years (electrical conductivity, previous years by evaporation). This is indeed unfortunate, since the last six years would have provided insight into how effective the TDS regulations have been in curbing the increasing TDS trend.

The least-squares fit indicates the TDS levels are increasing at a rate of 1.6 mg/l and 4.9 mg/l for the Mississippi and Illinois Rivers, respectively. Both rivers average TDS concentrations below 500 mg/l, which is the food processing standard; however, maximum values exceeding this water quality standard have on occasion occurred in the Illinois River. At Meredosia in 1971, a maximum TDS level of 580 mg/l was recorded, the highest level reported for the 20-year period. The maximum reported TDS concentration in the Mississippi at Chester also occurred in 1971; a value of 447 mg/l was measured in that year.

*Description of the Statistics: Utilizing a simple regression technique, the coefficient of the time factor with respect to the TDS mean concentration was determined. If, indeed, there has been no pattern to historical mean TDS levels, the coefficient of the time factor would not be discernible from "0". Using the t-statistic, the coefficient was tested and found to be significant at the 95% confidence interval. The actual t-values were 7.7 and 34.8 for the Mississippi and Illinois Rivers, respectively.

Least Squares Fit 1955-1971
 TDS = $341 + 4.9 (\# \text{ of Yrs.})$
 1955-1971 - Evaporation Test
 1972-1974 - Electrical Conductivity
 1975 - Evaporation Test at Valley City

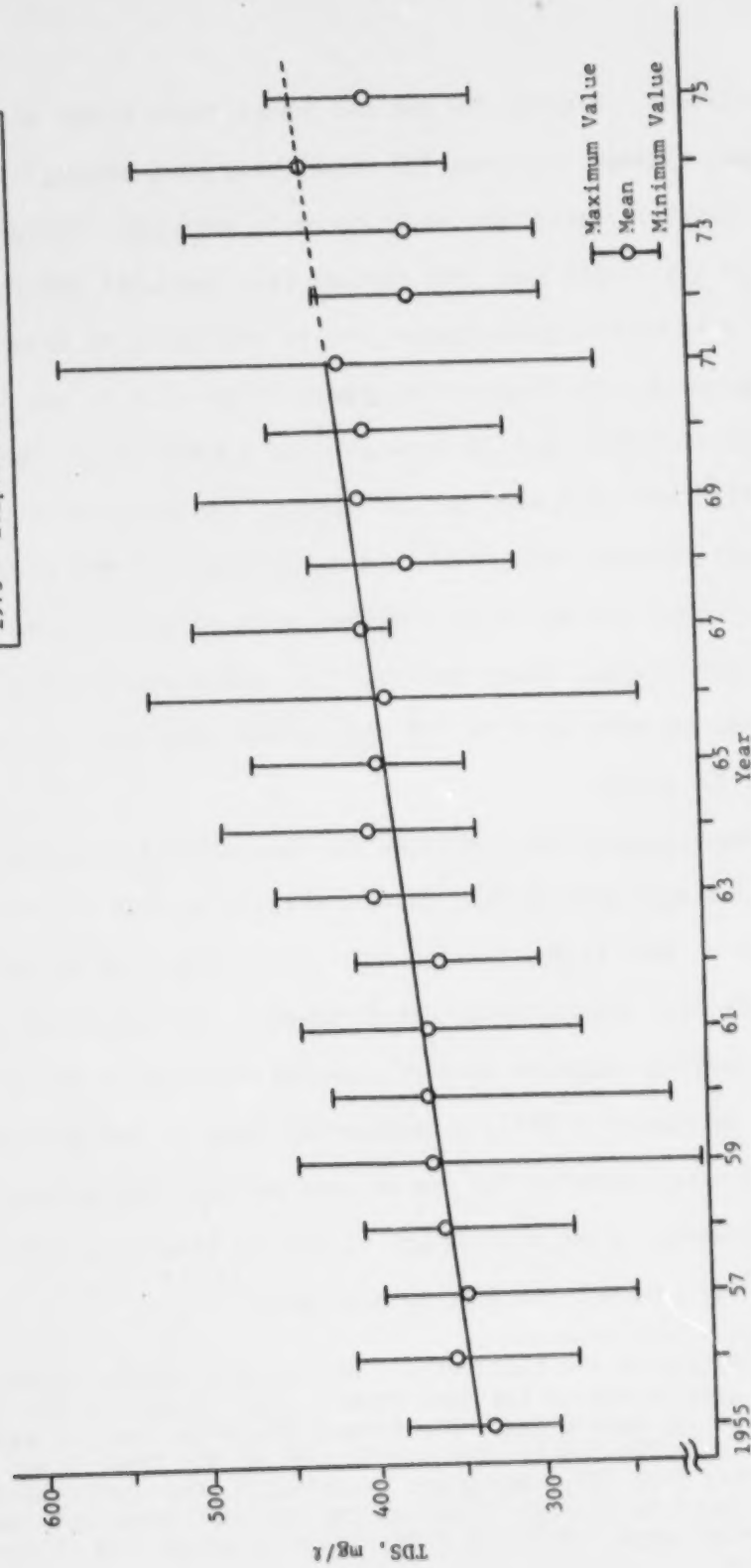


Figure 2-2 - ANNUAL TDS LEVELS IN ILLINOIS RIVER AT MEREDOSIA

Least Squares Fit 1955-1971
 TDS = 294 + 1.64 (# of Yrs.)
 1955-1971 - Evaporation Test
 1972-1974 - Electrical Conductivity

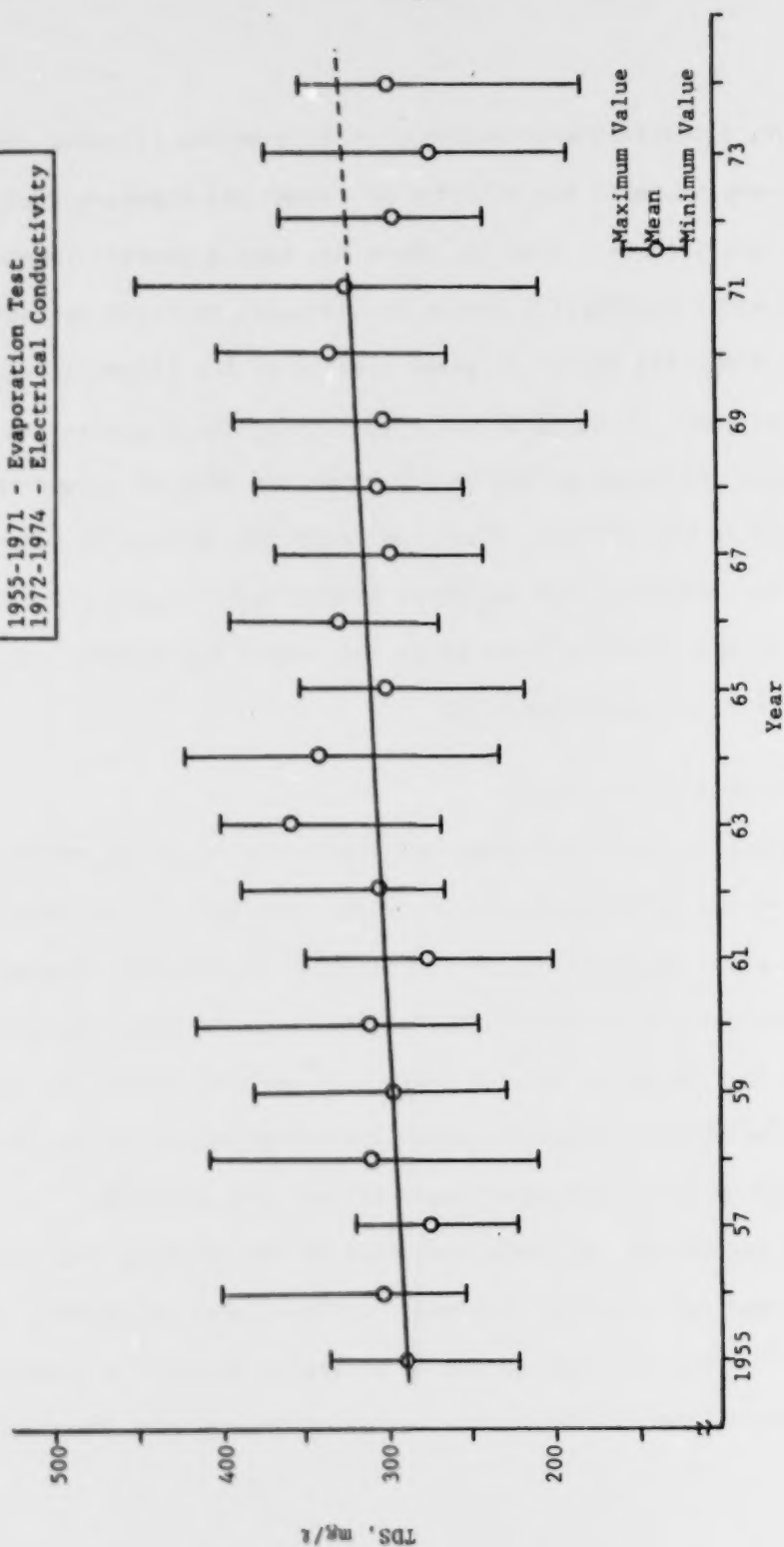


Figure 2-3 - ANNUAL TDS LEVEL IN MISSISSIPPI RIVER AT CHESTER

Thus, a least-squares analysis of data on the Illinois and Mississippi Rivers supports the findings of Flemal and Nienkerk described in the previous section. That is, there has been a general increasing trend in water quality TDS levels in Illinois, at least up until 1971.

The projected change in water quality of the Illinois River without the TDS effluent standard is of concern since there appears to be increasing TDS levels. Research by Van Meer¹¹ upon the role of conservative substances in the Illinois River indicates that even with future power generating capacities and non-point source contributions, the water quality in the Illinois River would not exceed the general use standard even at 7-day, 10-year low flows.

2.2.2 Projected TDS Levels

Projection of future water quality levels is a very difficult task because of the large number of variables involved. If industrial dischargers are a major source of TDS loadings in Illinois waterways, then the present effluent regulations should result in lower TDS water quality levels. The change in the TDS analytical methods adopted by IEPA precludes drawing any inferences about the effectiveness of the effluent regulation until several more years of data are collected.

The increasing TDS trend discussed in the previous section contrasts with the general trend for the major United States waterways. The U.S. EPA¹⁰ reported that of the 22 waterways across the country were investigated from 1963-1972, the following trends were observed:

<u>Parameter</u>	<u>Number of Reaches Analyzed</u>	<u>% of Reaches Improved</u>
TDS (105°C)	28	64
TDS (180°C)	23	61
Chlorides	34	62
Sulfates	33	55

The general increase in TDS levels in Illinois waterways observed over the past 20 years is the result of industrial dischargers contributions as well as TDS loadings from other sources, such as agriculture, storm-water run-off, and road de-icing. The specific sources and their contribution of dissolved solids to Illinois waterways are described in the next section.

2.3 Sources of TDS in Illinois

An important question, which this section addresses, is discerning the influence of industrial effluents on the overall TDS levels in Illinois. This is a very difficult issue to resolve. The results do provide an interesting perspective that should be considered in assessing the need for the current effluent TDS regulations.

2.3.1 A Previous Study on Illinois Water Quality

Flemal and Nienkerk^{1,2} investigated the regional characteristics of TDS in Illinois waterways. As discussed in Chapter 2, these authors found that the weighted average TDS level in Illinois waterways is 303 mg/l, which corresponds to an annual drainage rate of 222 tons of TDS/mi²/yr. This level is considerably higher than most "natural" streams found in the Midwest, and the authors state that the TDS drainage rate is twice that of the Mississippi River Basin as a whole.

Based on their results, Flemal and Nienkerk believe that the high

TDS levels are primarily attributed to non-point sources and regionally homogeneous sources, such as the Chicago area. As a preliminary estimate, the authors state that the TDS contributed by human activities (anthropogenic sources) is between 50 to 67% of the total TDS contribution. Flemal and Nienkerk did not attempt to estimate the quantity originating from various human activities, which is of primary importance in the establishment of TDS effluent standards.

2.3.2 Mass Balance on TDS Leaving the State of Illinois

An estimate of the magnitude of the TDS contribution received from various sources was considered an important factor in properly describing the status of TDS levels within the state. Thus, a mass balance of TDS in state waters was calculated for the major river basins.

There are seven major rivers that drain 94% of the total land in Illinois. These rivers, and their associated drainage areas, are listed below:

<u>River</u>	<u>Drainage Area, mi²</u>
Rock	10,800
Illinois	29,000
Kaskaskia	6,000
Big Muddy	2,400
Saline	1,000
Embarras	2,300
Vermillion	1,300
Total	52,800

Utilizing flow and TDS concentration data, the total quantity of TDS (lb/day) can be computed for various stream conditions. Shown in Table 2-4 is the minimum, median, and 90% TDS loadings for the seven

Table 2-4
MAJOR RIVERS DRAINING ILLINOIS

River	Drainage Area, mi ²	Flows, cfs				TDS, mg/l			Time Period of TDS Data, and Station
		7-day, 10-yr Low Flow	10% Flow	50% Flow	90% Flow	10% Conc.	50% Conc.	90% Conc.	
Rock	10,800	1,466	1,915	4,256	15,000	295	340	425	1961-1966 at Como
Illinois	29,000	3,600	6,070	13,700	41,000	333	404*	462	1966-1971 at Meredosia
Kaskaskia	6,000	147	205	1,640	15,600	190	340	460	1961-1966 at New Athens
Big Muddy	2,400	36	36	320	5,860	200	400	940	1956-1961 at Murphysboro
Saline	1,000	3	8	140	3,950	233	1,026	1,920	1971 at Ohio River Junction
Embarras	2,300	35	54	708	5,540	250	330	390	1956-1961 at Ste. Marie
Vermillion	1,300	42	47	332	2,175	180	450	710	1958-1965 at Danville
Totals	52,800	5,329	8,335	21,096	89,125				

*Mean value, median value is 413 mg/l

ivers. (A detailed discussion of the procedure and data utilized is presented in the Appendix.) The median quantity of TDS leaving the state is 44.1×10^6 lb/day, while the range is from 15.2×10^6 to greater than 139×10^6 lb/day.

Utilizing this median lb/day TDS value, one can attempt to identify the sources and quantify their contribution to TDS levels. The following descriptive list specifies eight major sources:

- Background TDS in Lake Michigan Water
3,200 cfs of water is withdrawn from Lake Michigan and discharged after use into the Illinois River System.
- Domestic Waste Contribution
Domestic sewage typically contains 200 mg/l more TDS than does the corresponding potable water supply.
- Municipal Ground Water Supply
Ground water after use is discharged to surface streams. Approximately 300 mgd of ground waters are used in Illinois by municipalities.
- Industrial Ground Water Supply
Industries in Illinois lift approximately 260 mgd of ground water which is also discharged to surface waters after use.
- Road De-Icing
Illinois currently uses 300,000 ton/year of salt for de-icing, most of which finds its way into the surface waters of the state.
- Irrigation
Approximately 140 square miles of land are irrigated in Illinois.
- Industrial Contribution
Industrial water use (excluding cooling water) is approximately 1,500 mgd. The estimated contribution, in lb/day, is presented in Table 2-5 for various categories by TDS concentration.
- Storm-Water Runoff
A major source of TDS is evidenced by the wide difference between the median and 90% TDS loadings shown in Appendix Table A-3.

Table 2-5
INDUSTRIAL TDS CONTRIBUTION

Industrial Category by TDS Conc. ¹ , mg/l	Mean TDS, mg/l	Mean TDS Contributed ² , mg/l	% of All Industrial Dischargers	Total Contribution ³ lb/day x 10 ⁻⁶
> 2,000	3,000	2,700	1.4	0.47
1,500-2,000	1,800	1,500	1.4	0.26
1,300-1,500	1,400	1,100	1.4	0.19
1,200-1,300	1,250	950	1.4	0.17
1,000-1,200	1,100	800	2.8	0.28
800-1,000	900	600	12.5	0.94
700- 800	750	450	16.7	0.94
600- 700	650	350	26.4	1.16
500- 600	550	250	36.0	1.13
Total			100.0	5.54

¹From Illinois EPA 1975 monitoring data

²Mean TDS minus mean background TDS in Illinois, 300 mg/l

³Based on total industrial flow of 1,500 MGD (excluding cooling water)

The Appendix includes a more detailed discussion of each of the above sources and the calculation of the contributions.

Based upon the identified sources of TDS and the estimated contribution from each source, Table 2-6 was prepared. The results indicate that storm-water runoff (urban and rural) contribute approximate 65% of the total pounds of TDS found in the rivers in Illinois. Three sources of industrial contributions are presented in Table 2-6; back-ground from industrial ground water supplies, industrial plants discharging less than 1,000 mg/l, and those plants discharging greater than 1,000 mg/l.

The industrial sector that discharges less than 1,000 mg/l was considered in compliance with the current TDS regulation of 750 mg/l above background. The industrial sector discharging greater than 1,000 mg/l was presumed to be adding the minerals to the water, as opposed to concentrating the minerals through evaporative cooling. This is indeed a harsh assumption, since many of the discharges above 1,000 mg/l TDS are the result of recycling cooling water, thus concentrating the minerals. The 1.5% of the TDS attributed to industrial dischargers with TDS concentrations over 1,000 mg/l is probably an over-estimate of their contribution.

The contribution by those industries discharging more than 1,000 mg/l can be placed into perspective by comparing the 1.5% with other sources. Several of the sources, including road de-icing, back-ground from Lake Michigan, and domestic waste, contribute more dissolved minerals than does the industrial sector discharging greater than 1,000 mg/l. Storm-water runoff alone contributes more pounds of

Table 2-6
TDS MASS BALANCE FOR ILLINOIS

Source	Average TDS Discharged to Illinois Waterways, 10 ⁶ lb/day	Percent of Total TDS ¹ Loading, %
Background from Lake Michigan	2.85	6.5
Domestic waste contribution	1.90	4.3
Background from municipal ground water	1.25	2.8
Background from industrial ground water	1.08	2.4
Road de-icing	1.64	3.7
Irrigation	0.19	0.4
Industrial contribution		
Dischargers <1000 mg/l	4.16	9.4
Dischargers >1000 mg/l		
Contribution of 1st 1000 mg/l	0.74	1.7
Contributions of >1000 mg/l	0.64	1.5
Storm-water runoff	<u>28.9</u>	<u>65.5</u>
Total	43.35	98.4

¹Average TDS leaving the state via the seven rivers presented in Table 2-4 is 44.1×10^6 lb/day.

TDS than all other sources combined. The industrial sector discharging greater than 1,000 mg/l is directly affected by the Illinois TDS effluent regulation, while the regulation has little or no effect on the other sources, which apparently account for 98% of the total TDS loading.

These mass balance estimates were reinforced by Van Meer's mass balance on the source contributions to the Illinois River TDS loading. Van Meer's results indicated that industrial point sources were "insignificant" in contributing to TDS loading.¹² According to the conservative substance model developed, point sources and non-point sources contributed 22% and 78% respectively of the total dissolved loading to the Illinois River.¹¹ In this model the Ship and Sanitary Canal was used as one point source discharge (and this would include the Metropolitan Sanitary District discharges). Excluding the MSDGC contributions, the point source discharges would represent 14%. Considering that the Illinois River represents a waterway with many point source (industrial and municipal) discharges, the state-wide estimate of industrial discharges loading of 12.6% seems appropriate.

2.3.3 Significance of the Mass Balance Results

While the estimated contributions of TDS to the waters of Illinois are only crude approximations, they do provide interesting results. If the magnitude of industrial TDS loading is correct, then only a small portion of the total TDS can be satisfactorily controlled through effluent regulations. From Table 2-6, it is apparent man's activities contribute much of the overall TDS found in the rivers of Illinois.

Flemal and Nienkerk estimated that man's activities may contribute from 1/2 to 2/3 of the TDS loading. Excluding the storm-water runoff, all of the other sources used in this estimation (which are a result of man's activities) account for 1/3 of the total loading. Much of storm-water runoff can also be attributed to man, such as fallout of atmospheric sulfur, fertilizer loss, and urban storm-water collection and discharge systems. Thus, Table 2-6 supports the conclusions of Flemal and Nienkerk concerning man's influence on the TDS level. However, the industrial dischargers affected by the effluent standard appear to account for only a small part of man's influence.

Chapter 3

BENEFITS OF REGULATION

3.1 Impacted Population

The benefits of eliminating the total dissolved solids effluent regulation accrue to those industrial dischargers concerned with control of TDS. Presently these dischargers may exceed the standard or have specific NPDES permit limitations for total dissolved solids. These dischargers are identified herein, and the savings in treatment costs and monitoring expenses are calculated as benefits for adopting the proposed change.

The three discharger segments affected by the proposed regulation are the potable water treatment plants, electric utility companies, and miscellaneous dischargers. The source of TDS, compliance levels, and potential reduction in costs associated with the proposed change are described for each of these discharger groups herein.

3.1.1 Potable Water Treatment Plants

There are currently 150 municipalities in Illinois that utilize zeolite softeners for upgrading the quality of their potable water supplies. All of these municipalities utilize well water for their raw water source. Zeolite softeners are typically used by small towns (less than 1 million gallons per day) because of the simplicity in operation. Larger municipalities apply a lime softening process, which requires considerably more manpower and a higher operator skill level than the zeolite softeners.

Regeneration of the zeolite filters results in a concentrated salt stream that is either discharged to the municipal waste treatment plant or discharged directly into a receiving stream. The direct dischargers of brine wastes not only exceed the "add 750 mg/l TDS" standard, but also 3500 mg/l TDS limit. To date, the IEPA has encouraged the zeolite users to discharge into the city sewers so that the waste is diluted. Of the 150 zeolite softening plants, 87 are direct dischargers to streams. The choices remaining for these zeolite users are indeed limited. Municipalities have basically three choices; cease softening altogether, convert to lime softening at a higher cost, or haul the waste brine stream by truck to the closest waste water treatment plant. If the water treatment plants cease softening altogether, homes could install their own water softener system. Home water softeners are less efficient than the commercial zeolite softeners, thus more pounds of TDS will ultimately be added to the environment from this option.

Lime softening is an expensive alternative which is not economical for these small softening plants. Rather than install new equipment, the direct dischargers were assumed to cease softening or haul away the brine waste.

The savings in water treatment costs resulting from adoption of the proposed regulatory change have been estimated for the two alternative actions. Table 3-1 presents the annual cost savings and capital investment savings for municipal water treatment plants if the TDS effluent standard is eliminated.

The savings of Table 3-1 are based upon an affected population of 121,681 in 87 municipalities. The specific calculation methodology is

Table 3-1
SAVINGS TO POTABLE WATER TREATMENT PLANTS

Treatment Option	Annual Savings	Capital Investment Savings
a. Savings if homeowner had to install own softening unit (zeolite softening plant ceased operation)	\$493,000-1,649,000	\$9,126,000
b. Savings if brine hauled away	\$7,694,000	\$ 870,000

included in the appendix; however, the general methodology is based upon unit savings multiplied by the number of affected households or affected people. Both options "a" and "b" involve substantial savings for capital investment and operating costs, respectively, if the proposed change is adopted.

3.1.2 Electric Generating Stations

Total dissolved solids limitations appear in the NPDES permits for effluents from electric generating stations. These limits pertain to the dissolved solids generated from two sources, softeners for boiler feed water and from ash pond overflow. Regeneration of the softeners results in a concentrated brine stream similar to small potable water plants. Although this brine stream is small compared to the quantity of cooling water utilized at each power station, compliance is required prior to combination with this cooling water.

Table 3-2 lists those electric generating plants which currently have TDS limitations on their discharges. Those fourteen stations have

Table 3-2

ELECTRIC GENERATING STATIONS WITH EFFLUENT TDS LIMITATIONS

Company	Plant	TDS Limitation, mg/l
Commonwealth Edison	Waukegan (regeneration waste)	3500
	(ash pond)	Δ750
Commonwealth Edison	Christian Co.	3500
Commonwealth Edison	Dixon	5906
Commonwealth Edison	Ridgeland	Monitor
Commonwealth Edison	Joliet	3500
Commonwealth Edison	Kincaid	Monitor
Commonwealth Edison	Zion	Monitor
	Crawford 001	3500
	002	Δ750
Electric Energy		Δ750
Illinois Power	Baldwin	Monitor
Illinois Power	Vermilion	Monitor
Illinois Power	Havana	Monitor
Central Illinois Public Service	Grand Tower	Δ750
Central Illinois Public Service	Coffeen	
WIPCO	Pearl	Δ750

permit limitations which require a limit of "add 750 mg/l TDS", 3500 mg/l TDS, or of a unique TDS value for 16 dischargers. In 1977 Commonwealth Edison received a variance from the IPCB for total dissolved solids effluent limitation, and this variance extends until the end of 1979. No treatment costs for only TDS control have been incurred to date by electric generating stations although the potential does exist after 1979.

The savings directly attributed to elimination of the TDS effluent standard are reduced analytical costs. Each plant monitors TDS with a frequency varying from twice weekly to monthly only samples. Utilizing an average analytical cost of \$7.50 per sample,* and an estimated number of 64 samples per month (16 discharges and 1 sample per week), the analytical savings is calculated as \$5760 per year.

3.1.3 Miscellaneous Affected Dischargers

In reviewing the IEPA effluent monitoring records for 1976-1977 all waste water sources with greater than 1,000 mg/l total dissolved solids were identified. These dischargers are categorized in Table 3-3 according to discharger type and level of TDS in the effluent. Five sources reported concentrations exceeding 3500 mg/l in 1977-1978; one municipality, and four chemical companies. The dischargers between 1000 mg/l to 3500 mg/l may or may not be in violation of the law, depending on the following conditions: intake water TDS level; amount of water recycle; and receiving stream characteristics. There are 80 point sources who discharge less than 3500 mg/l but more than 1000 mg/l. These

*The \$7.50 represents an average of prices obtained from three laboratories.

Table 3-3
SUMMARY OF DISCHARGERS WITH MAXIMUM TDS LEVELS GREATER THAN 1000 mg/ℓ

Discharger Type	Number of Dischargers with TDS Concentrations (mg/ℓ)						Total
	1000-1250	1250-1500	1500-2000	2000-2500	2500-3500	>3500	
Municipalities	20	5	10	3	1	1	40
Foods	1	1	-	1	-	-	3
Chemicals	2	1	2	-	-	4	9
Petroleum Products	-	-	2	-	-	-	3
Metal Fabrication	-	1	1	-	-	-	2
Utilities	2	1	-	-	-	-	3
Miscellaneous	<u>12</u>	<u>4</u>	<u>2</u>	<u>1</u>	<u>1</u>	-	<u>20</u>
Total	37	13	17	5	3	5	80

Source: IEPA Monitoring Data, 1976-1977.

dischargers could be potentially impacted. Only 19 dischargers, however, have TDS limits in their permit.

Table 3-4 identifies those dischargers who exceeded 3500 mg/l TDS between 1974 and 1977, according to IEPA data. These dischargers do not comply with existing TDS effluent regulations and could incur costs to assure compliance.

Table 3-4
DISCHARGERS OUT OF COMPLIANCE

Firms in 1974-1975 over 3,500 mg/l TDS	Firms in 1976-1977 over 3,500 mg/l TDS
Carus Chemical	Carus Chemical Company
Livingston Nursing Home	National Starch Company
Allied Chemical (subsurface)	Sauget STP*
Illinois Tollway Building	B. F. Goodrich
Taylorville S.D.	SCM Corp. - Glidden Durkee
Park City South, Inc.	
Philadelphia Quartz	
Woodstock Die Casting	

*Received special exemption from TDS effluent limitation.

Source: IEPA Monitoring Data

The savings in costs associated with these miscellaneous dischargers consists of reduced monitoring expenses for 19 dischargers and/or eliminate the need for additional treatment of the effluent for four dischargers. Since the cost of a total dissolved solids analysis is

estimated at \$7.50 per sample, the expected savings in analysis is equivalent to \$6840 per year.*

Those dischargers out of compliance must make either in-plant changes or augment their waste treatment facilities. To assess the maximum potential savings, reverse osmosis treatment costs were estimated for the impacted dischargers. Table 3-5 presents the expected costs, and the specific calculations for capital investment and operating expenses are included in the appendix. A maximum total capital investment of \$6.6 million and operating expenses of \$538,900 per year would be saved by elimination of the effluent TDS regulation.

3.2 Summary of Expected Benefits

The benefits gained from elimination of the proposed regulation consist of reduced costs for 87 potable water treatment plants, reduced analytical costs, and elimination of reverse osmosis treatment for four industrial dischargers. Table 3-6 presents the saved capital investment and annual operating costs for the three discharger categories described.

*Analytical savings per year = 4 samples/month x 19 dischargers x
12 months/year x \$7.50/sample.

Table 3-5
REVERSE OSMOSIS COSTS FOR INDUSTRIAL DISCHARGERS

Discharger	Capital Investment* (\$, million)	Annual Operating Cost, (\$ per year)
B. F. Goodrich	2.56	215,700
Carus Chemical	0.66	29,000
National Starch	1.32	104,200
Glidden Durkee	<u>2.06</u>	<u>190,000</u>
Total	\$6.6	\$533,900

*Based upon RO plant sizes as follows:

1. B. F. Goodrich - 0.61 mgd
2. Carus - 0.04 mgd
3. National Starch- 0.24 mgd
4. Glidden Durkee - 0.51 mgd

Note: Costs in 1977 dollars

Table 3-6
TOTAL SAVINGS TO IMPACTED DISCHARGERS

Discharger Group	Annual Savings, \$ \$, millions	Capital Investment Eliminated, \$, millions
Water treatment plants		
or option a	0.49-1.65	9.13
option b	7.69	0.87
Electric generating station		
monitoring	0.006	-
treatment	-	-
Miscellaneous		
monitoring	0.007	-
treatment	0.54	6.6
Total ¹	1.044-8.25	\$7.47-15.73

Note: ¹Totals reflect the inclusion of either option "a" or "b" under water treatment plants.

Chapter 4

COSTS OF REGULATORY CHANGE

4.1 Impacted Water Uses

The proposed deletion of the total dissolved solids (TDS) effluent standard will impose costs upon users of surface waters. There are approximately fourteen water use categories which could be potentially impacted by increased concentrations of total dissolved solids. The effect of TDS upon each category is described, and then the estimated costs of expected changes in water quality are presented.

4.1.1 Aesthetics

The aesthetics related to control of TDS is mainly a function of the taste in drinking water. The U.S. Public Health Service has recommended a standard of 500 mg/l TDS in drinking water supplies. The actual composition of the dissolved solids in water is important in determining the threshold taste level. As was noted in the 1962 Drinking Water Standards,⁹ "there may be a great difference between a detectable concentration and an objectionable concentration of neutral salts."

Lockhart, Tucker, and Merritt investigated the taste threshold level of various ions on brewed coffee⁹ and determined that 400 to 500 mg/l chlorides or 800 mg/l of sulfate as $MgSO_4$ affected the taste of coffee. In terms of TDS concentrations, such levels would be above 500 mg/l and probably close to 1,000 mg/l. The TDS level at which water becomes "completely unusable" is 5,000 mg/l, according to the 1962 U.S. Public Health Service Drinking Water Standards.

In the State of Illinois, only one major river, the Saline River, contains TDS concentrations greater than 1,000 mg/l and supplies the drinking water for Harrisburg and Carrier Mills. At this level, there could be some loss of aesthetics as a result of water taste, depending upon the ions present. Those counties associated with the Saline River are Gallatin, Hardin, Hamilton, Saline, and Williamson. The source of high solids in this river basin is not industrial but is rather attributed to mining activities. Since mining discharges are not affected by the proposed regulations, no aesthetic costs are incurred.

4.1.2 Agriculture Costs

In 1968, there were 61,000 farm acres in Illinois that were irrigated.⁴ The total number of irrigated acres in Illinois is expected to increase to 245,000 acres by the year 2020, or to 26% of the total irrigable soils in Illinois.⁴ The dissolved solids content of the irrigated water is of prime concern because of potential reductions in crop yields attributed to high mineral waters.

The effect of salinity on crop production has been investigated by many researchers. The following are suggested guidelines for salinity in irrigation waters presented in a Department of Interior study:

	<u>TDS, mg/l</u>
Water for which no detrimental effects will usually be noticed	<500
Water which can have detrimental effects on sensitive crops	500-1,000
Water that may have adverse effects on many crops	1,000-2,000

The three major crops in Illinois--corn, soybeans, and wheat--are

not considered salinity-sensitive crops. The following relationship between salinity and yield have been developed for these crops⁷ :

	TDS Concentration where Yield Reduction Is Initiated, mg/l	Rate of Yield Reduction Above Threshold, % Yield Reduction/100 mg/l TDS
Corn	1,000	2.5
Wheat	3,000	1.2
Soybean	2,500	4.0

The reductions in crop yields are related to the average TDS concentration in the water supplied. Irrigation, in Illinois, usually supplies only a small portion of the total crop moisture requirement, most being furnished by normal rainfall.⁴ Thus, TDS levels in Illinois waterways would have to be above 1,000 mg/l before any measurable loss of agricultural output could be discerned.

Of the seven major Illinois waterways described in Chapter 2, only the Saline River has a mean TDS concentration above 500 mg/l. The Saline River, as shown previously in Table 2-4, has a mean TDS concentration of 1,026 mg/l. Thus, if sensitive crops are grown in this river basin, and if irrigation constitutes a major source of water for the crops, some reduction in crop yields may occur. The number of acres in the Saline River Basin under irrigation provides a crude measure of the farmer's dependence upon irrigation. The following is a list of counties in the Saline River Basin, and their respective acres under irrigation:

<u>County</u>	<u>Acres Irrigated, 1968</u>
Gallatin	80
Hardin	0
Hamilton	0
Saline	3
Williamson	0

Again, the effects of high dissolved solids in this river basin are attributed to mining activities and these activities are unaffected by the proposed regulatory change.

Thus, because Illinois receives sufficient rainfall to provide a major portion of the crop moisture requirements, irrigation is not practiced as extensively as in the western states. The current TDS concentrations in other Illinois waterways are well below any harmful level for agricultural use. Complete elimination of the TDS regulation would have no measurable effect on agricultural production. A similar conclusion was also reached by the Natural Resources Development Board in 1970⁴. In their report to the Governor, they stated:

Concentration of minerals in irrigation groundwater has therefore not been reported as a problem nor is it expected to be one in the foreseeable future. Recycling of Illinois surface waters has likewise not caused build-up of mineral content adverse to irrigation.

4.1.3 Commercial Fishing

If TDS stream concentrations were detrimental to commercial fish growth, reproduction, or lifespan, then an increase in TDS would impose a cost upon commercial fishermen. Commercial fishermen utilize the major river basins in Illinois and only small operations exist on the Illinois River. TDS levels in these rivers are below 500 mg/l, and no loss of commercial fishing is associated with the proposed change.

4.1.4 Residential Water Supplies

The presence of dissolved minerals in residential water supplies inflicts some damage on appliances and personal items in contact with the water. Even at low concentrations of TDS, corrosion and accelerated depreciation of household appliances occur. The useful service life of household plumbing fixtures and appliance appears to be directly related to the TDS concentration in the water. Hardness, which may or may not be related to the TDS concentration, depending on the water source, results in scale deposits in water heaters and increased consumption in soap and detergents. Because hardness is indirectly controlled by TDS effluent regulations, hardness was considered in the benefit analysis for TDS.

Tihansky⁸ provided a summary of the literature regarding the damage costs of TDS and hardness in residential water supplies. Tihansky then proceeded to develop his own, much more comprehensive estimate of the related damages of TDS and hardness. Table 4-1 lists the items for which Tihansky was able to develop mathematical relationships between damage and TDS. Utilizing the damage estimates for the items in Table 4-1, Tihansky then developed the existing damage costs for each state; and the results for Illinois are presented in Table 4-2.

The average per capita damage in Illinois from TDS in treated surface waters is \$15.05 per year. The average TDS level in Illinois water is 303 mg/l. Dividing the per capita cost by the average TDS concentration in that state yields a damage cost of:

$$\frac{\$0.05/\text{yr/capita}}{\text{mg/l TDS}}$$

Table 4-1
HOUSEHOLD ITEMS DAMAGED
BY TDS AND HARDNESS

<u>Item</u>	<u>Affected by</u>
Bottle water	TDS
Cooking utensils	TDS
Faucets	TDS
Garbage grinders	TDS
Sewage facilities	TDS
Soap and detergents	Hardness
Toilet facilities	TDS
Washable fabrics	TDS
Washing appliances	TDS
Wastewater piping	TDS
Water heaters	TDS
Water piping	TDS
Water softeners	Hardness
Water utility systems:	
distribution	TDS
production	TDS
service lines	TDS
storage	TDS
water meter	TDS

Table 4-2
EXISTING DAMAGE COSTS TO RESIDENTIAL WATER SUPPLIES
IN ILLINOIS

Item	1970 Dollars	1978 Dollars ¹
<u>Annual Damage by Source</u>		
Treated surface	51.6 x 10 ⁶	85.1 x 10 ⁶
Treated ground	61.9 x 10 ⁶	102.1 x 10 ⁶
Well	56.7 x 10 ⁶	93.6 x 10 ⁶
Total	170.2 x 10 ⁶	280.8 x 10 ⁶
<u>Per Capita Damages by Source</u>		
Treated surface	9.12	15.05
Treated ground	19.14	31.58
Well	25.49	42.06
Total	15.31	25.26

¹Cost updated by 1970 Dollars x $\frac{\text{Consumer Price Index 1978}}{\text{Consumer Price Index 1970}} = 1.65$

1970 CPI = 117

1978 CPI = 193

In other words, each 1 mg/l increase in dissolved solids results in five cents of damage per capita per year.

To determine the effect of eliminating the TDS effluent regulation, the annual damage of surface waters due to TDS of \$85.1 million must be considered. In Chapter 2 the total contribution of industrial dischargers with TDS effluent concentrations greater than 1000 mg/l would be a maximum of 1.5%. Only 19 of 79 industrial and municipal dischargers exceeding 1000 mg/l have TDS limitations in their NPDES permits, and 14 electric generating plants monitor TDS. The calculated change in industrial TDS loading would be an average of 6%. No change in TDS level occurs due to elimination of the zeolite softening plants. Thus, the annual residential damage cost incurred would be equal to the following:

$$\$85,100,000/\text{year} \times 0.031 \times 0.06 = \$158,000$$

4.1.5 Ecology

The effect of TDS on the vegetation, wildlife, and general environment is a direct function of the concentration considered. According to Water Quality Criteria,¹⁰ the osmotic concentration of the body fluids of a fresh water animal is the maximum level that can be tolerated. Values above 1,500 mg/l of sodium chloride adversely affect fresh water mollusks. In Table 4-3, a summary is presented of various animal and plant species, and the corresponding TDS or chloride concentrations at which some biological effect is discerned. These levels described in the Water Quality Criteria book are quite high, and no TDS effect in Illinois waters of less than 500 mg/l would be anticipated based on Table 4-3.

Table 4-3
ECOLOGICAL EFFECTS OF TDS

Species	TDS or Chloride Concentration, mg/l	Effect Noted
Chicken, Turkeys	3,000-5,000 (as chloride)	Death and retarded growth
Chlorella algae	6,000 (as chloride)	Growth inhibited
Waterfowl food plants	60,000 (as chloride)	Detrimental effects
Poultry	2,860 (TDS)	Threshold concentration
Swine	4,290 (TDS)	Threshold concentration
Horses	6,435 (TDS)	Threshold concentration
Dairy cattle	7,150 (TDS)	Threshold concentration
Sheep (adult)	12,000 (TDS)	Threshold concentration

Source: Water Quality Criteria, 1968.

Testimony presented by the Illinois EPA at the TDS Regulatory Hearing summarized the fish-related literature; a portion is summarized below:

In water of 1,300 micromhos (845 mg/ TDS), eggs of fathead minnow, northern pike, and walleye hatched well, but when salinity reached 4,000 micromhos (2,600 mg/) there was no hatching of walleyes, a very poor hatch of northern pike eggs, but a good hatch of fathead minnow eggs.

The following table on bluegills and diatoms was taken from the testimony presented by the Illinois EPA.

Compound	96-hr TL _m for Bluegill,	120-hr TL _m for Diatom Nitzschia Linearis,
	mg/l	mg/l
CaCl ₂	10,650	3,130
CaSO ₄	2,980	3,200
NaCl	12,946	2,430
Na ₂ SO ₄	13,500	1,900
Na ₂ CO ₃	320	242
NaHCO ₃	8,600	650
KCl	2,010	1,337

Within Illinois, the general stream quality is below 1,000 mg/l of TDS for most streams. The Saline River contains the highest TDS concentrations, as discussed in Chapter 2. While there may be ecological damage in some Illinois waters due to the existing TDS levels, the literature indicates the damage would be small at the existing TDS concentrations. Because of the many other parameters besides TDS which influence the ecological balance in the streams, a major undertaking would be required to assess any damage associated with TDS. Thus, no general estimation of ecological losses from adoption of the regulatory proposal has been developed.

4.1.6 Human Health (Ingestion and Water Contact)

The U.S. Public Health Service has recommended a 500 mg/l level of TDS, primarily based on taste effects. More than 100 water supplies across the United States have TDS levels in excess of 2,000 mg/l. Acclimatization to these levels is needed, but no ill effects have been reported.⁹ The other additional effect, which is attributed to magnesium and sodium sulfate, is a laxative effect. Waters with 600 to 1,000 mg/l sulfates are recognized to produce laxative effects, especially on unacclimatized persons.

The health effects associated with surface water users in the state are expected to be insignificant. At the present TDS levels in Illinois waterways, no health effects were reported in the literature.

4.1.7 Industrial Water Supply

Industrial users of surface waters for process and cooling purposes may experience economic damages due to high TDS levels. Damage to water pipes, boilers, plumbing, and other equipment can be incurred as the result of dissolved solids in water. In a report completed on the Los Angeles River Basin,⁵ the damage cost for an industrial user was estimated at \$4.69/ac-ft/ 100 mg/l TDS, or \$0.014/1,000 gallons/ 100 mg/l TDS in 1967. Upgrading the cost to 1978 dollars yields a damage factor of \$0.025/1,000 gal/100 mg/l TDS. Each incremental reduction in TDS can be associated with reduced costs to industrial users.

In the appendix to Chapter 2, the industrial water consumption was estimated at 1,500 million gallons per day. Approximately 250 million gallons of this amount is withdrawn from wells and the remainder is

surface water. Having established the mean TDS level in the state at 303 mg/l and the potential reduction in TDS with enforcement of the present standard as 0.19%, the approximate average statewide industrial savings can be estimated. Enforcing compliance of the current regulation would reduce the average TDS levels by 0.6 mg/l. At an economic cost of \$0.025 per 1,000 gallons per 100 mg/l TDS, the total annual industrial costs would be \$68,000 as calculated below.

$$\frac{\$0.025}{1,000 \text{ gal}-100 \text{ mg/l}} \times \frac{0.6 \text{ mg/l}}{1} \times \frac{1,250 \times 10^6 \text{ gal}}{\text{day}} \times \frac{365 \text{ days}}{\text{year}} = \$68,400/\text{year}$$

Of course, the individual industrial operation costs would vary with surface water utilized; however, as an average, the estimate of \$228,000 offers a magnitude of potential costs.

4.1.8 Power Generation

The industrial generation of power was included in the previous section discussing industrial consumers. Thus, this section deals primarily with the use of water in the utility industry.

In general, the major water use in steam generation is for condenser cooling water. The estimated damage cost of TDS on the cooling water system is based on the Water Quality Criteria recommended minimum TDS quality of 1,000 mg/l and the estimated plant life of 28 years. The details of the derivation of the damage cost is presented in the Appendix to Chapter 4. A damage value of \$0.00021/l 1,000 gal/100 mg/l was derived for the power-generating industry, as compared to \$0.025/1,000 gal/100 mg/l for industrial water. The major difference between these two values is that the power-generating industry water use is over 99% once-through cooling, while the major

fraction of industrial water supply is for other uses.

In 1965, the entire water usage of the power industry in Illinois was approximately 13,500 mgd. To determine the effect of TDS in surface waters, those plants utilizing cooling water impoundments or lakes should be excluded. With the growth in the power generation industry since 1965, there is probably closer to 20,000 mgd utilized for cooling purposes today. However, only about half of the plants utilize the streams in Illinois, (the other half utilizing man-made cooling lakes and Lake Michigan which are unaffected by the TDS standard.) For calculation purposes, a water use rate of 10,000 mgd was utilized. As stated previously, rigorous enforcement of the TDS effluent standard would reduce the TDS levels in Illinois waterways by an average of 0.6 mg/l. The annual costs to the electric utility industry from this reduction would be :

$$\frac{\$0.00021}{1,000 \text{ gal}-100 \text{ mg/l}} \times \frac{0.6 \text{ mg/l}}{1} \times \frac{10,000 \times 10^6 \text{ gal}}{\text{day}} \times \frac{365 \text{ days}}{\text{year}} = \$4,600$$

4.1.9 Recreation (Water Contact)

Recreational activities, such as swimming or water skiing, are probably only indirectly affected by TDS levels in the water. Activities would be reduced in waters which were aesthetically unpleasing or unpalatable. No direct costs have been ascertained for the State of Illinois due to the existing TDS levels which are, in general, below any aesthetic threshold concentration.

4.1.10 Recreation (Water Non-Contact)

Recreational activities which are considered non-contact water

sports primarily relate to fishing, boating, and camping. The effects of TDS on aquatic life were discussed in the ecology section. The costs to other areas within the state in terms of aquatic effects could not be defined without extensive data collection and biological evaluations, however, these also appear to be small.

4.2 Expected Costs

Adoption of the regulatory proposal will result in no improvement of water quality. The costs of existing water quality have been measured across thirteen potential user categories. In Table 4-4 the results of these estimations are summarized for the State of Illinois.

Within the State of Illinois three user groups, residential water supplies, industrial water supplies, and utilities, were identified as receiving specific economic damage from dissolved solids in water. The residential water users represented the most significant group with a potential reduction in economic damages of \$158,000 per year. Total costs to surface water users equalled \$231,000 for the three uses specified.

Table 4-4
SUMMARY OF TDS ECONOMIC COSTS

Potential Water Use	Potential Loss to Water User
Aesthetics	Not measured
Agricultural Benefits	Negligible
Commercial Fishing	Negligible
Residential Water Supply	\$158,000/year
Ecology	Not measured
Human Health	Negligible
Municipal Water Supply	Included in residential water supply
Industrial Water Supply	\$63,400/year
Navigation	None
Power Generation	\$4,600/year
Property Value	None
Recreation	<u>Negligible</u>
Total	\$231,000

Chapter 5

COSTS AND BENEFITS OF THE REGULATORY CHANGE

5.1 Introduction

The measurement of the costs and benefits of an effluent regulation provides an indication of the accompanying resource allocation. In many instances, real-world constraints on data and quantification of benefits in dollar terms limit the practicality of applying a benefit-cost analysis. The benefit-cost analysis of a TDS regulation is not as straight-forward as that for a toxic or hazardous material. Toxic substances which damage human health and aquatic life must be removed by dischargers to protect the environment. There really is no alternative for removal of these materials, which can so quickly damage the environment. Pollutants, such as TDS, primarily affect consumers who withdraw surface water for various purposes. Thus, it is possible to consider alternatives to effluent treatment, such as TDS removal by the public water supplies, for minimizing TDS quantities reaching the consumer.

Through a discussion of all potential costs associated with TDS regulation, some insight is provided on the value of the existing effluent standard.

5.2 Costs of Regulation

In evaluation of effluent standards, the "results" of compliance have been considered achievement of a certain level of water quality. To obtain this level of water quality, costs are imposed on one group, while benefits are bestowed on another. The social welfare criterion,

known as the Pareto criterion,* does not cover the public policy decisions related to pollution control since there is always a group which is made worse off by the control of pollution. Therefore, the general criterion utilized in this benefit-cost analysis is that of Kaldor-Hicks, which states that a change in resource allocation should be considered as an increase in welfare if the Pareto criterion is met or if those gained from the reallocation could compensate those who were harmed leaving them as well off as before.³ Translated into the application of benefit-cost analysis, the net effect of a project or policy should yield benefits in excess of costs. Maximization of this difference (willingness to pay less costs of providing it) is considered the "efficiency" objective.

5.3 Benefit-Cost Analysis

A comparison of the benefits and costs of TDS regulation offers an indication of the economic efficiency of adopting the regulatory proposal. By aggregating the potential economic damages incurred in 13 user segments due to TDS, we have gained some insight as to the amount of benefits which would offset these damage costs.

In Illinois the total projected costs and benefits of the effluent TDS standard were also estimated. Potential economic damage to domestic water users, industrial sources, and power plants totalled \$231,000 per year. This value can be compared to the savings in treatment costs and analytical costs required to bring the current TDS violators into compliance of between \$1 million to \$8 million. The treatment costs are

*Pareto criterion of social welfare states that any change in social state is "desirable" if at least one person judges himself to be better off while no one else is made worse off by the change.

based on the use of reverse osmosis, with the range attributable to the method utilized for brine disposal. Both the statewide costs and the benefits of TDS control appear to be significant on a general basis. However, the total benefits do exceed the costs to be realized, which satisfies the Pareto and Kaldor-Hicks criteria. The benefits considered in the statewide analysis represent only economic damages which have been quantified. In individual circumstances within the state there may be sufficient benefit to TDS reduction to impose an effluent standard; however, the water quality standard would also be an appropriate enforcement mechanism. These statewide estimates offer some perspective of the effect of the present effluent standard on the economic allocation of resources within the state.

The economic impact of eliminating the TDS effluent standard is based upon increased operating costs for surface water users and savings to potable water treatment plants, electric generating stations, and industrial dischargers. No impact upon agricultural or commercial activity is observed as a result of the rule change. Nineteen industrial dischargers will reduce analytical costs and potential treatment requirements by \$538,900 per year while all other industrial surface water users will continue to incur slightly higher operating costs totalling \$68,400 per year. This continued operating cost of \$68,400 should not affect industrial output or product price.

The total state population served by surface water sources will continue to incur costs of \$158,000 per year in wear of household items. However, the annual savings of \$493,000 to \$7,694,000 will be achieved for 121,681 people in 87 communities. No increase in municipal services

or taxes beyond existing levels will occur as a result of the rule change.

Chapter 6

OVERVIEW OF THE ANALYSIS

6.1 Limitations to the Analysis

The use of cost-benefit analyses has been limited in the past, primarily due to the lack of an adequate data base. Where reliable data have not been developed, simplifying assumptions are necessary to complete the analysis. A list of the major assumptions and methodologies utilized in this study have been completed as a limitation to the analysis. Each item is described briefly, and its potential effect on the benefit-cost analysis or economic impact is quantified where possible.

1. Number of Dischargers Violating the TDS Standard

The effluent standard allows each discharger to add 750 mg/l TDS above the background water quality; however, allowances are made for recycling and other pollution abatement practices up to a maximum of 3,500 mg/l. Thus, each discharger actually has a unique TDS effluent standard (anywhere from 1,000 to 3,500 mg/l TDS), depending upon the degree of recycling. The number of dischargers in violation of the 3,500 mg/l standard was readily ascertained; however, the number of dischargers in violation of the law below 3,500 mg/l cannot be determined. In Chapter 2, only dischargers with TDS levels specified in their permits were assumed to reduce TDS levels in the state. This assumption underestimates the actual industrial contribution that could be controlled through rigorous enforcement of the standard. However, the total treatment costs to bring industry into compliance and the total benefits of the regulation are both based upon this same number of dischargers.

2. Variation in Analytical Test Method

Variation in total dissolved solids analytical techniques has made it difficult to project water quality trends and actual effluent levels. The IEPA, in their routine monitoring of water quality and effluents, utilize specific conductivity to estimate TDS. The correlation between specific conductivity and actual TDS level varies for each waterway and discharger. Since the IEPA utilizes only one conversion factor for all specific conductance analyses, the accuracy of their results is suspect.

In Chapter 2, the water quality trend with time was plotted for the Illinois and Mississippi Rivers. The IEPA specific conductance data had to be utilized for 1972-74, which are the key years since the adoption of the TDS standards in Illinois.

3. Treatment Costs

A range of treatment costs was provided because of the uncertainty over the method of brine disposal. Obviously, the ultimate treatment costs are a function of the actual TDS loading and the ultimate disposal method acceptable to the IEPA.

6.2 TDS Effluent Regulation for the State of Illinois

In Chapter 2, the major sources of TDS and their contributions to the waterways were identified. The industrial contribution was broken down into two segments: those discharging TDS in levels less than 1,000 mg/l and those discharging greater than 1,000 mg/l. The contribution from these two sources were as follows:

Industrial dischargers < 1,000 mg/l TDS -- 4.3%

Industrial dischargers > 1,000 mg/l TDS -- 3.1%

Only 19 dischargers with TDS levels greater than 1,000 mg/l were presumed to be in violation of the existing "add 750 mg/l" standard. At the present time, there are no TDS removal systems (reverse osmosis, electro-dialysis, evaporation, etc.) for dissolved solids utilized by industrial dischargers in Illinois. Rigorous enforcement of the effluent standard could reduce the state-wide TDS loading by a maximum of 0.6 mg/l. The value of an environmental regulation that excludes 97% of the pollution loading should be considered by the Pollution Control Board. Where a concentration of industries or small receiving streams results in excessive TDS levels in a stream, water quality standards offer an alternative to controlling industrial dischargers. Rigorous

enforcement of the water quality standards would allow the IEPA to maintain control over the dischargers in the problem areas.

The estimated state-wide annual savings in costs for compliance with the existing TDS regulation varied from \$1 million to \$8 million. This cost was based upon the use of reverse osmosis by the affected dischargers with greater than 1,000 mg/l TDS in their effluent. Because the interpretation of the current regulation has resulted in unique compliance levels between 1,000 and 3,500 mg/l for each discharger, the actual compliance status could not be readily ascertained for each discharger.

Costs were estimated using the same TDS reduction basis as utilized for the costs. Reduced economic damage to domestic water users, industrial sources, and power plants totalled \$231,000 per year. These values represent state-wide estimates; however, on a case-by-case evaluation, the magnitude of the marginal analysis could certainly fluctuate. These gross numbers are only presented to indicate the approximate existing situation within the State of Illinois.

The TDS regulations within other states were examined and are summarized in the Appendix to Chapter 6. In no other state is there a numerical effluent standard for TDS; however, the increase in stream concentration over background was identified as a criterion utilized by several states for discharge regulation.

In evaluating the isolated discharger cases, it is important to be aware of the overall water quality within the state, the potential damages which may occur due to an amendment to the standard, and the actual enforcement consequences of the regulation. The overview of the

state's TDS water quality and effluent situation provides the background for the decision-making process regarding the regulation of total dissolved solids.

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APPENDICES

Appendix to Chapter 2

SOURCES OF TOTAL DISSOLVED SOLIDS IN ILLINOIS

MASS BALANCE ON TDS LEAVING THE STATE OF ILLINOIS

There are seven major rivers that drain 94% of the total land in Illinois. Table A-1 lists these seven rivers, their drainage areas, flows, and TDS concentrations. The Illinois River alone drains 55% of the entire state, and thus carries a major portion of the state's dissolved solids load to the Mississippi.

In Table A-2, the TDS values not exceeded 10% and 90% of the times on a concentration and pounds per day basis are presented for the Illinois River. The 10% TDS concentration values occurred at flows above the mean, with four of the six flow values above the 90% frequency level. The TDS concentration values above the 90% frequency level took place at flow values close to the mean. All of the flows were above the 10% value. Based upon pounds per day of TDS instead of concentration, the results are quite different. The 10% TDS levels (in lb/day) all occurred at low flow periods with close to the mean TDS concentrations. The 90% TDS loadings all happened at high flows and five of the six values were at the 10% TDS concentration.

The above results indicate that the flow rate has considerable influence on the pounds per day of TDS entering the Mississippi River. This would suggest that storm-water runoff may be the major contributor to TDS (on a pounds per day basis) to the Illinois River, and perhaps other rivers in the state.

In Table A-3, the variation in TDS loading for each major river is presented. The median TDS level leaving the state is 44.1×10^6 lb/day, with a range from 15.2×10^6 to $139. \times 10^6$ lb/day. At the minimum level, or 15.2×10^6 lb/day, the flow and TDS contribution from storm water runoff should be negligible,

Table A-1
MAJOR RIVERS DRAINING ILLINOIS

River	Drainage Area, mi ²	Flows, cfs				TDS, mg/l			Time Period of TDS Data, and Station
		7-day, 10-yr Low Flow	10% Flow	50% Flow	90% Flow	10% Conc.	50% Conc.	90% Conc.	
Rock	10,800	1,466	1,915	4,256	15,000	295	340	425	1961-1966 at Como
Illinois	29,000	3,600	6,070	13,700	41,000	333	404*	462	1966-1971 at Meredosia
Kaskaskia	6,000	147	205	1,640	15,600	190	340	460	1961-1966 at New Athens
Big Muddy	2,400	36	36	320	5,860	200	400	940	1956-1961 at Murphysboro
Saline	1,000	3	8	140	3,950	233	1,026	1,920	1971 at Ohio River Junction
Embarras	2,300	35	54	708	5,540	250	330	390	1956-1961 at Ste. Marie
Vermillion	1,300	42	47	332	2,175	180	450	710	1958-1963 at Danville
Totals	52,800	5,329	8,335	21,096	89,125				

*Mean value, median value is 413 mg/l

Table A-2

RANGE OF TOTAL DISSOLVED SOLIDS
IN THE ILLINOIS RIVER

	TDS Conc., mg/l	Flow, cfs	
Mean	404	--	Time Period: 1967-1971
Value not exceeded:			Location: Meredosia
10%	339	6,070	
50%	404	13,700	
90%	462	41,000	

10% TDS Concentration Values		
TDS, mg/l	Flow, cfs	Month
312	47,600	2
313	27,600	5
304	56,700	2
314	15,500	11
339	63,700	4
333	75,400	6

90% TDS Concentration Values		
TDS, mg/l	Flow, cfs	Month
462	15,800	3
502	19,000	12
498	9,470	12
472	14,200	1
580	8,210	2
540	10,200	5

10% TDS Loading, lb/day			
TDS, lb/day x 10 ⁻⁶	Flow, cfs	TDS, mg/l	Month
12.4	5,900	391	10
16.5	7,560	406	9
17.6	7,530	433	11
15.0	7,740	359	9
11.9	5,200	425	9
12.6	5,750	418	10

90% TDS Loading, lb/day			
TDS, lb/day x 10 ⁻⁶	Flow, cfs	TDS, mg/l	Month
83.2	49,200	314	10
80.0	47,600	312	2
92.9	56,700	304	2
83.9	36,700	424	4
116.4	63,700	339	4
135.3	75,400	333	6

Source: R. H. Harmeson, et al., "Quality of Surface Water in Illinois, 1966-1971".

Table A-3
VARIATIONS IN TDS LOADINGS

River	Minimum TDS ¹ , lb/day x 10 ⁻⁶	Median TDS ² , lb/day x 10 ⁻⁶	90% TDS ³ , lb/day x 10 ⁻⁶
Rock	2.7	7.8	23.9
Illinois	11.9	29.8	80.0
Kaskaskia	0.3	3.0	16.0
Big Muddy	0.1	0.7	6.3
Saline	--	0.7	3.0
Embarras	0.1	1.3	7.5
Vermillion	0.1	0.8	2.1
Total	15.2	44.1	139.0

¹ 10-yr, 7-day low flow and median TDS concentration

² Median flow and median TDS concentration

³ 90% flow and 10% TDS concentration

while all other major sources of TDS should remain relatively constant over a year's period. Thus, the difference between the median and minimum TDS loading is considered attributable to storm water runoff, or 28.9×10^6 lb/day, or 65.5% of the total TDS found in the streams that drain Illinois. Estimates of the other important sources of TDS are presented below.

CONTRIBUTIONS TO THE TDS LEVELS IN ILLINOIS

Background TDS in Lake Michigan Water

The Cook County area withdraws an average of 3,200 cfs from Lake Michigan. All of this water will eventually leave the state via the Illinois River. The mean TDS level of Lake Michigan water is 165 mg/l, which yields 2.85×10^6 lb/day of TDS withdrawn that ends up in the waters of the Illinois River.

Domestic Waste Contribution

The national per capita increase in TDS found in domestic wastewater varies from 100-300 mg/l (Metcalf and Eddy, 1972). Using a per capita consumption of 100 gal/day and an average TDS increase of 200 mg/l, the loading is 0.17 lb/day/capita. While some people of Illinois use septic fields, the bulk of the population is served by sanitary sewers. Assuming the wastewater from 11 million people in the state will leave the state via the seven major rivers shown in Table A-1, the total contribution from domestic waste is 1.87×10^6 lb TDS/day.

Municipal Ground Water Contribution

Approximately 300 MGD of ground water is pumped out of the ground by municipalities (Water for Illinois, A Plan for Action, 1967). Utilizing a typical TDS level of 500 mg/l for ground water, an estimated 1.25×10^6 lb/day of TDS is contributed to the rivers from municipal ground water supplies.

Industrial Ground Water Contribution

Industrial plants in Illinois utilize approximately 260 MGD (Water for Illinois, A Plan for Action, 1967) of ground water, which

after use is discharged to the rivers of the state. Assuming a background TDS level of 500 mg/l , this is equivalent to 1.08×10^6 lb/day of TDS.

Road De-Icing

According to the Salt Institute (1974), 0.3×10^6 ton/year of salt are applied to the highways in Illinois, or an annual average of 1.64×10^6 lb/day. A study in Chicago (American Public Works Assn., 1969) indicated that nearly 100% of the salt applied to highways finds its way into the waterways. Thus, the entire 1.64×10^6 lb/day of salt applied was assumed to contribute to the TDS in the seven river basins.

Irrigation

In many of the western states, irrigation is a major contribution to the TDS found in the rivers. Israelsen and Hansen (1962) reported TDS increases from 7.4 to 77.0 mg/l per river mile attributed to irrigation. In Illinois, approximately 140 square miles are irrigated. The TDS increase reported per stream mile cannot be directly applied, since the area irrigated is not reported. However, if one assumes that the salt picked up from irrigation is similar to that from storm water runoff, then the same factors can be utilized. Flemal and Nienkerk (1975) reported annual runoff values of 97-320 ton/mi²/yr. Assuming a value of 250 ton/mi²/yr for irrigation, the total contribution to the TDS level in Illinois is 0.19×10^6 lb/day.

Industrial Contribution

In 1965, the total industrial use of water, exclusive of cooling water, was 1,443 MGD (Water for Illinois, A Plan for Action, 1967). Many industries in the state have reduced their water usages over the last five years, and thus it is doubtful this water usage has increased to any great extent over the past 11 years. For our purposes, we have assumed that industrial water usage is 1,500 MGD.

The Illinois EPA samples nearly every discharger in the state each year. From the EPA's data, one can obtain a frequency distribution of TDS concentration discharged to Illinois waterways. Assuming that any discharger above 500 mg/l is non-cooling water, and assuming the flow rates in each category are uniformly distributed, one can compute the total contribution of the industrial dischargers. This computation is shown in Table A-4. The total industrial contribution was estimated at 5.54×10^6 lb/day, of which 75% was discharged by firms within the effluent regulation, background TDS level plus 750 mg/l TDS.

Table A-4

INDUSTRIAL TDS CONTRIBUTION

Industrial Category by TDS Conc. ¹ , mg/l	Mean TDS, mg/l	Mean TDS Contributed ² , mg/l	% of All Industrial Dischargers	Total Contribution ³ , lb/day x 10 ⁻⁶
> 2,000	3,000	2,700	1.4	0.47
1,500-2,000	1,800	1,500	1.4	0.26
1,300-1,500	1,400	1,100	1.4	0.19
1,200-1,300	1,250	950	1.4	0.17
1,000-1,200	1,100	800	2.8	0.28
800-1,000	900	600	12.5	0.94
700- 800	750	450	16.7	0.94
600- 700	650	350	26.4	1.16
500- 600	550	250	36.0	1.13
Total			100.0	5.54

¹From Illinois EPA 1975 monitoring data²Mean TDS minus mean background TDS in Illinois, 300 mg/l³Based on total industrial flow of 1,500 MGD (excluding cooling water)

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b) Haul away brine

Assume disposal cost of \$0.07/gal (existing industrial charge)

Capital cost based on holding tank addition at cost of \$10,000 per tank times 87 tanks or \$870,000.

$$\begin{aligned}\text{Operating cost} &= 301,142 \text{ gal/day} \times 365 \text{ days} \times \$0.07/\text{gal} \\ &= \$7,694,000\end{aligned}$$

Calculation of Reverse Osmosis Costs for Industrial Dischargers

A) Methodology

- 1) Size of treatment plant based upon achievement of 200 mg/l TDS in RO effluent and combination of treated and untreated stream resulting in effluent of 2000 mg/l.
- 2) RO costs based upon Figure A4-1 and A4-2 from Huff, L., Economic Impact of Dissolved Solids Regulation Upon the Coal Mining Industry, IIEQ Document No. 77/28.
- 3) The following industrial costs were based upon the flows and concentrations indicated:
 - a) B. F. Goodrich - Average flow = 0.926 mgd
TDS concentration = 5800 mg/l
 - b) Carus Chemical - Average flow = 0.083 mgd
TDS concentration = 3700 mg/l
 - c) National Starch - Average flow = 0.3 mgd
TDS concentration = 4300 mg/l
 - d) Glidden Durkee - Average flow = 0.64 mgd
TDS concentration = 4600 mg/l
- 4) Capital investment is determined by RO plant size from Figure A-1 in mgd x 1.65 to update costs to 1977.
- 5) Operating costs in \$/1000 gallons are determined from

Figure A-2. Then, annual cost equals the following:

$$\begin{aligned} \text{Cost} &= \$/1000 \text{ gallons} \times \text{RO volume} \frac{\text{gal}}{\text{day}} \times 365 \text{ days} \\ &\quad \times 1.70 \text{ (up to date cost)} \end{aligned}$$

ESTIMATED BENEFITS TO THE POWER GENERATION INDUSTRY
AND STATEWIDE TREATMENT COSTS

TDS EFFECT ON POWER GENERATION

The primary use of water in the electric utility industry is for cooling purposes. The damage cost of \$0.021/1,000/gal/100 mg/l TDS utilized for industrial water supply is probably a high estimate for the power generation industry, where once-through cooling water is the major source. The recommended TDS level for cooling and condensing waters is below 1,000 mg/l (Water Quality Criteria, 1968), although some power plants located near the oceans utilize sea water (35,000 mg/l TDS). Presumably, the criteria for cooling and condensing water is established to insure the piping, etc. will last the expected life of the plant. The estimated life of a fossil fuel plant is 28 years, (U.S. Treasury Dept. Publication No. 456 (7-62), July 1962). Assuming that TDS is the major depreciation factor on the water piping, pumping, and condensers, one can compute the damage cost. The following is an estimate of the costs for the major components affected by surface waters for a 1000 MW oil-fired plant.

<u>Item</u>	<u>January 1971 Dollars</u>
Circulating Water Pumps (M)	\$ 420,000
(L)	50,000
De-icing water supply pumps (M)	70,000
(L)	15,000
Intake and Discharge Lines (M)	293,000
(including excavation) (L)	458,000
Warming Lines (M)	62,000
(L)	69,000
Discharge Tunnel (M)	225,000
(including excavation) (L)	452,000
Condensers (M)	2,015,000
(L)	500,000
TOTAL	\$4,629,000

Updating to 1975 Dollars = \$6,400,000

At 8% interest and 28 years, this is an annualized capital cost of = \$580,000/year

United Engineers and Constructors Inc., "Volume IV - Oil-Fired Fossil Plant - Investment Cost Study", U.S. AEC Report Wash-1230, June 1972.

A 1,000-MWE plant will use approximately 900 MGD cooling water. Converting to the same basis as was utilized for the industrial water users yields

$$\frac{\$580,000}{\text{year}} \times \frac{\text{year}}{365 \text{ days}} \times \frac{\text{day}}{900 \times 10^6 \text{ gal}} \times \frac{1,000 \text{ mg/l TDS}}{100 \text{ mg/l TDS}}$$

$$= \$0.00018/1,000 \text{ gal/100 mg/l TDS}$$

As compared to the industrial water estimate of \$0.021/1,000 gal/100 mg/l, the power industry value is a factor of 100 lower. We believe, however, that the estimated value is more realistic than the industrial value. (If the industrial value is utilized, the damage cost for a water supply of 1,000 mg/l TDS would be ten times the entire replacement cost each year. This is obviously a gross overestimate.)

Appendix to Chapter 6

SUMMARY OF EXISTING WATER CRITERIA
AND REGULATIONS FOR TOTAL DISSOLVED SOLIDS

The presence of dissolved solids in the streams and rivers of the United States is a natural occurrence. According to the National Advisory Technical Committee¹¹,

"Water devoid of dissolved materials is intolerable in nature because pure water will not support aquatic life."

Recommended water quality limits for dissolved minerals are presented for the various uses of water. These values are derived from federal water criteria which has been used in establishing state water quality standards.

The general water criteria summarized in Table A-5 are based upon a literature review of aesthetic and toxic effects for each user segment. The protection of humans, animals, fish, and vegetation covers a wide range of TDS concentrations from 500 to 10,000 mg/l. In waters designated as public water supplies, a TDS limit of 500 mg/l is recommended for aesthetic (taste) and psychological reasons. It is interesting to note that some public water supplies have TDS levels in excess of 500 mg/l. For example, the Illinois State Water Survey Bulletin No. 40 reports the following TDS levels in water supplies :

<u>Illinois Community</u>	<u>TDS, mg/l</u>
Braidwood	1,199
Cuba	2,380
Glasford	1,866
Ipava	2,953
Table Grove	3,106

Irrigation of sensitive crops requires water with TDS levels between 500 to 1,000 mg/l. Above this level, a reduction in crop yield will result for the most sensitive crops. All of the other water quality criteria presented in Table A-5 suggest higher TDS levels than recommended for public water supply, general farmstead use, and irrigation of sensitive crops.

Table A-5
WATER QUALITY CRITERIA¹

<u>Protected Use</u>	<u>Total Dissolved Solids, mg/l</u>
Public Water Supply	500
Freshwater Organisms	1,500 (as NaCl)*
Wildlife	5,000 (as NaCl)
General Farmstead Use	500
Livestock	10,000
Irrigation	
Water with adverse effects on sensitive crops	500-1,000
Water with adverse effects on many crops	1,000-2,000

* 1,500 mg/l increase in TDS or 1/3 over background

Source: National Technical Advisory Committee, Water Quality Criteria, FWPCA, April 1, 1968.

The water quality standards for various states are summarized in Table A-6 to indicate the variety of existing limitations. Only two types of effluent regulations have been used in other states, although there may be water quality limitations as well which would influence effluent TDS levels. In Nebraska, a discharger cannot increase the stream concentration of TDS by more than 10% or 20%, depending upon the stream. Ohio also has a restriction which limits TDS contributions from "human activities" to less than 150 mg/l for certain streams. Although over twenty states have adopted water quality TDS standards, Illinois is the only state to specify TDS concentrations in the effluent of dischargers.

Water quality standards utilized in other states vary from monthly averages to specific TDS limits according to the stream classification. The range of TDS water quality standards goes from 250 mg/l to 2,500 mg/l. If individual stream specifications were further examined, an even wider range of limitations would occur. The monthly average water quality standard for TDS is used in six states. This method acknowledges fluctuations due to stream flow conditions, runoff, and salting activities which may temporarily exceed water quality limitations.

Table A-6

SUMMARY OF STATE REGULATIONS
FOR TOTAL DISSOLVED SOLIDS

State	Total Dissolved Solids in mg/l	
	Effluent	Water Quality
Alaska	--	500 - drinking water
Arkansas	--	425-450 for Mississippi R. 500 - unlisted streams
Delaware	--	250
Florida	--	500 as monthly average 1,000 as maximum value
Indiana, Kentucky, Michigan	--	500 as monthly average 750 maximum
Iowa	--	750
Louisiana, Texas, Oregon	--	Varies according to stream
Minnesota	--	500 - Class A domestic 700 - Class A wildlife 1,000 - Class B wildlife
Mississippi	--	750 - monthly average } general 1,500 - maximum } standard 400-425 Mississippi R.
Nebraska	Discharger not to increase Class A stream concentra- tions by more than 10% and Class B by 20% or no more than 100 mg/l.	600 - Class A domestic 1,500 - Class B
Nevada, New Mexico	--	500 - Class A, B, C, or 1/3 above background
New York, Tennessee, Virginia, North Dakota	--	500
Ohio	150 mg/l attributed to human activity.	500 - monthly average 750 - maximum
Pennsylvania	--	500-1,500
South Dakota	--	1,000-2,500